

OPEN SYSTEMS Workshop





An Open Systems Approach to Weapon System Acquisition





Chartered by the Under Secretary of Defense for Acquisition and Technology in Nov 1994

Mission:

To champion the establishment of an open systems approach for the acquisition of all weapons systems.





This workshop will help you find answers to the following questions:

- What is an open systems approach and why do we need to pursue one?
- ✓ How are you going to take advantage of emerging products and technologies?
- **✓** How do you ensure a future technology insertion capability?
- **✓** How are you going to control cost?
- **✓** How are you going to evolve your system over its extended lifetime?
- ✓ How are you going to mitigate risks?
- **✓** What provisions have been made to ensure competition throughout the program life cycle?

Overview



Part I Why an Open Systems Approach?

Part II What is an Open Systems Approach?

Part III How do you implement an Open

Systems Approach?

Part IV Who is using an Open Systems Approach?

Overview



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	Approach?		

Acquisition Challenges









DoD no longer "drives" development. Instead, it must use what industry has developed for commercial applications.

DEVELOPER & PRODUCER



BUYER & INTEGRATOR

Acquisition Challenges DoD Acquisition Cycle



DoD cannot afford a 15-year acquisition cycle Electronics Industry Systems Cycle Time

DEVELOP

Constantly evolving by is is 1.5 to 2 Years

MARKET

DESIGN

DEVELOP

DESIGN

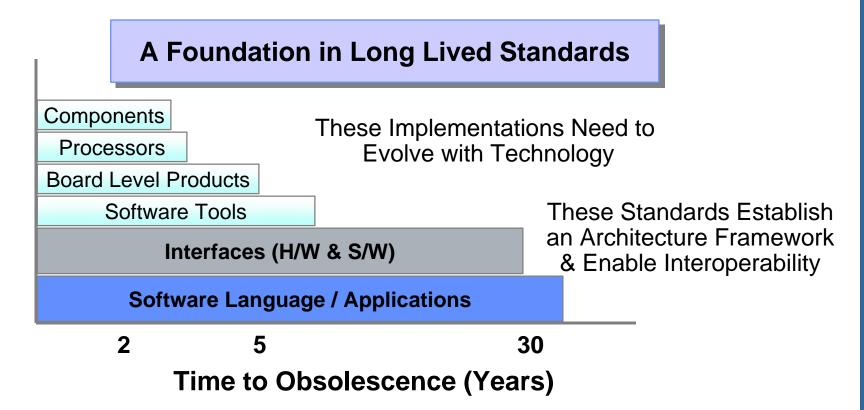
Major DoD Systems Cycle Time 8–15 **Years**

DEPLOY

Commercial market incorporates new technology 4 to 8 times faster



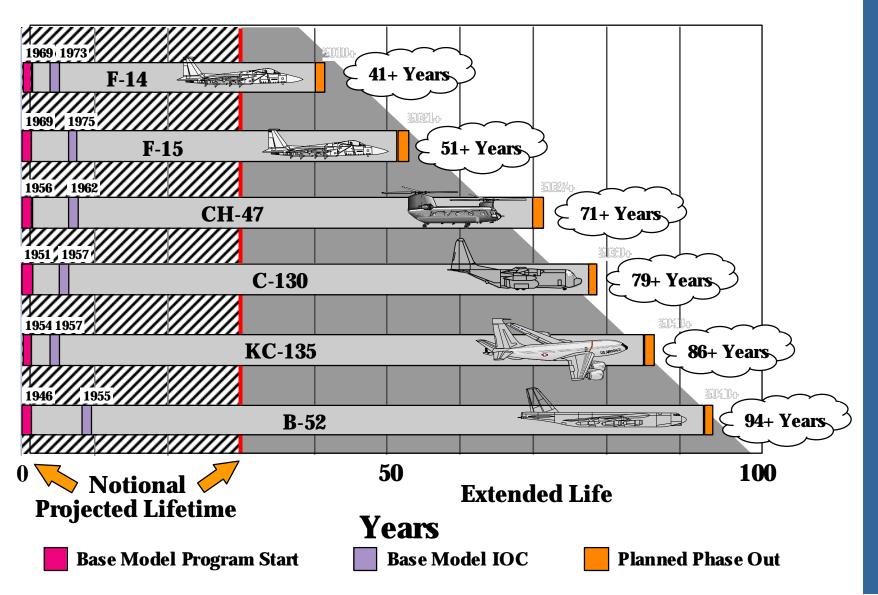
Architectural Framework for Affordability



Source TI Presentation

Acquisition Challenges Weapon System Life Cycles





Acquisition Challenges... Other Difficulties



- Unique, Closed Weapons Systems Designs
 Cost Too Much to Develop
 Cost Too Much to Support
 Cost Too Much to Modify
 Can Not Readily Employ New Technologies
 Inter-operation Is Less Than Desirable
- Declining Military Specialty Market



Dealing With Challenges Acquisition Initiatives



Cost as an **Independent Variable**

Trade Performance and Schedule for Lower Costs

Objectives:

Reduced Cycle Times and Total Ownership Costs; **Enhanced Interoperability**

Performance Based Requirements

State requirements in terms of needs, not designs

Clear Accountability in Design

Government Controls Performance -- Contractor Designs the Solutions.

Acquisition Reform

Non-Developmental and Commercial Items

Use Existing Technology and Products, If Applicable

Horizontal Technology Insertion

Evolutionary Acquisition

ON SYSTEMS IS AN ENABLER Modernization

Modernization Through Spares

Dealing With Challenges Acquisition Initiatives



- Replacement of military processes by commercial-like processes
 - Conversion of more than 200 facilities to ISO 9000 standards (saving \$500 million)
 - F-22 modules produced on commercial rather than military line
- Logistics on Demand
 - Integrating supply chains
 - Exploiting electric commerce
 - Shift from product procurement to purchase of services
- Single Process Initiative
- Other Transaction Authority Initiative
 - Providing better access to commercial technology providers



DoD's Open Systems Vision

DoD uses open systems to leverage commercial products and practices in order to field superior warfighting capability more quickly and more affordably.



Overview



Part I	Why an O	pen Systems .	Approach?
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An Open Systems Approach is an integrated business and technical strategy that employs a modular design and, where appropriate, defines key interfaces using widely supported, consensus-based standards that are published and maintained by a recognized industrial standards organization.





Modular designs are characterized by the following:

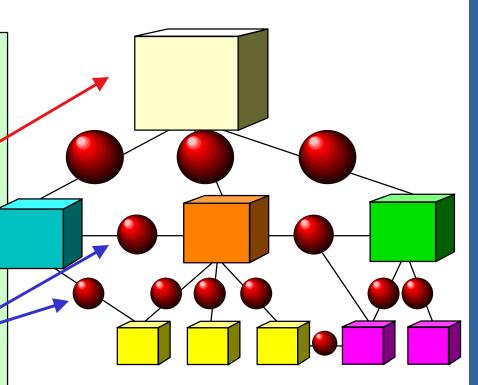
- Functionally partitioned into discrete scalable, reusable modules consisting of isolated, self-contained functional elements
- Rigorous use of disciplined definition of modular interfaces, to include object oriented descriptions of module functionality
- Designed for ease of change to achieve technology transparency and, to the extent possible, makes use of commonly used industry standards for key interface



The Open Systems Concept (1)

The foundation of an Open Systems Approach is a modular design

- Functionally partitioned
- Disciplined definition of modular interfaces
- Designed for ease of change



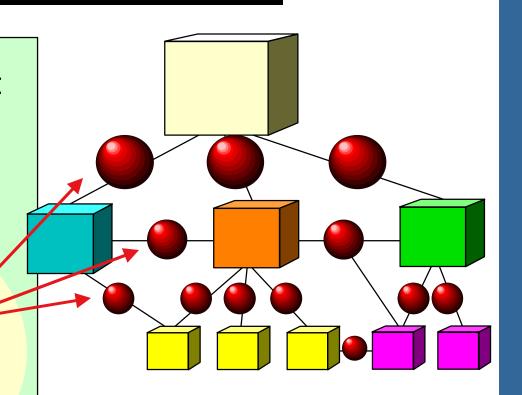


The Open Systems Concept (2)

Open Systems is all about managing *interfaces*!

DoD's focus is on the **Interfaces**

Producers choose the **Implementations**



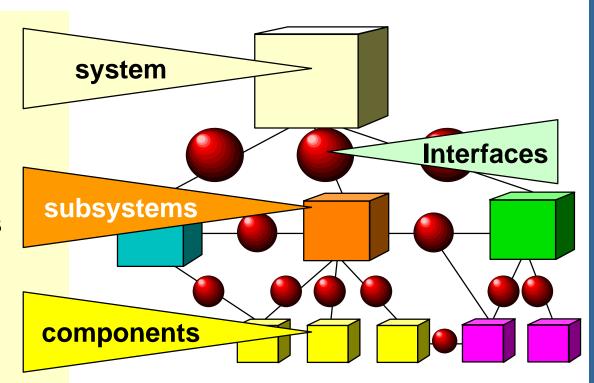


The Open Systems Concept (3)

A system - is a collection of interacting...

...subsystems - which are collections of interacting...

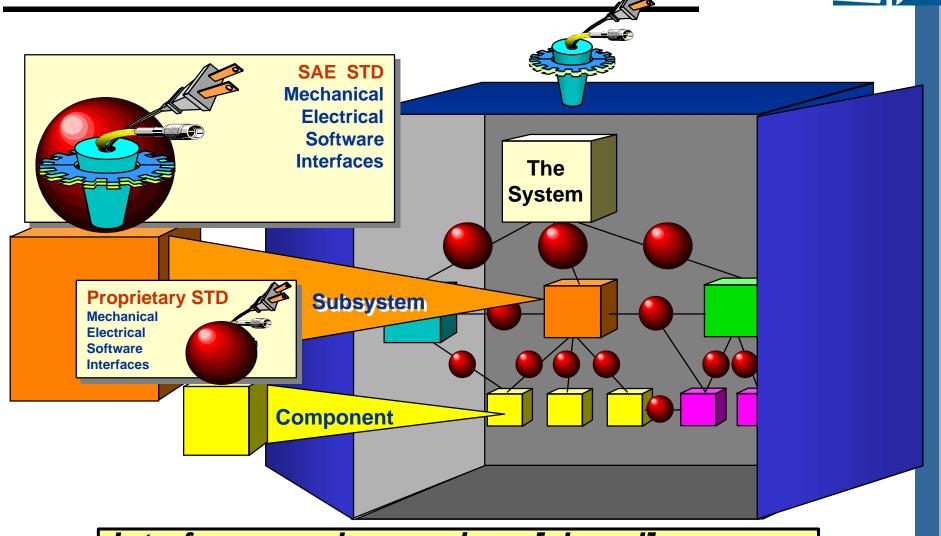
...components either hardware,
software, or human, ...



...that are connected by **interfaces** - to support the interchange of information, activity, or material essential to the functioning of the system.

The Open Systems Concept (4)



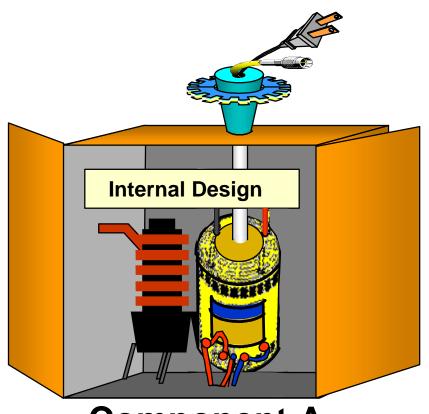


Interfaces can be: unique [closed], or consensus-based & widely-accepted [open]

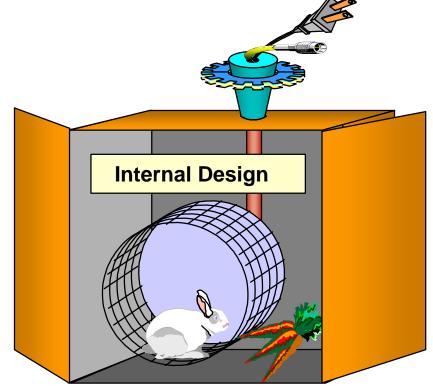
The Open Systems Concept (5)



<u>Developer</u> chooses a design to meet selected interface specification.



Component A



Component B

Open Standards



Standards that are widely used, consensus based, published and maintained by recognized industry standards organizations.

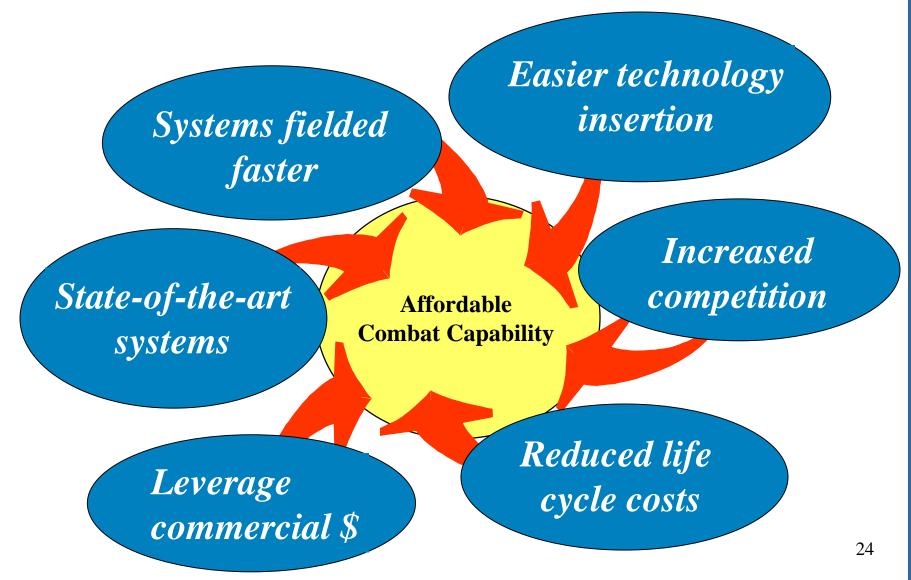
When to Implement Open Systems



- Available technologies with demonstrated military utility
- Technologies/engineering for full capability still need to be developed.(application of time-phased requirements)
- Longer-term requirements addressed as evolving increments
- High dependence on rapidly evolving technology
- Long-term supportability and upgrade needs within pre-defined cost constraints
- Need for design flexibility, modularity, and interface control
- Need for minimizing integration risks over the life of the system
- Taking advantage of competition throughout the life cycle



Benefits of Open Systems



Potential Risks





- Government becomes a consumer instead of the designer less control over outcomes
- Open Systems may not provide the <u>optimum</u> design for modules, components, subsystems and short-term solutions

Building Open Systems takes time for

- Market analysis
- Prototyping
- Standards Selection
- Cost Analysis
- The standards selection process has risks
- Open Interface *extensions* may cause problems later in the life cycle
- Supportability Risks

Summary



An Open Systems approach:

- An integrated business and technical strategy
- Functionally partitioned modular design
- Disciplined definition of modular interfaces
- Designed for ease of change
- Uses consensus-based interface definitions where appropriate.
- Allows supplier's design efforts, creativity, and current technology satisfy warfighter requirements
- Fully assess potential benefits and risks before implementing open systems

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Implementing an Open Systems Approach



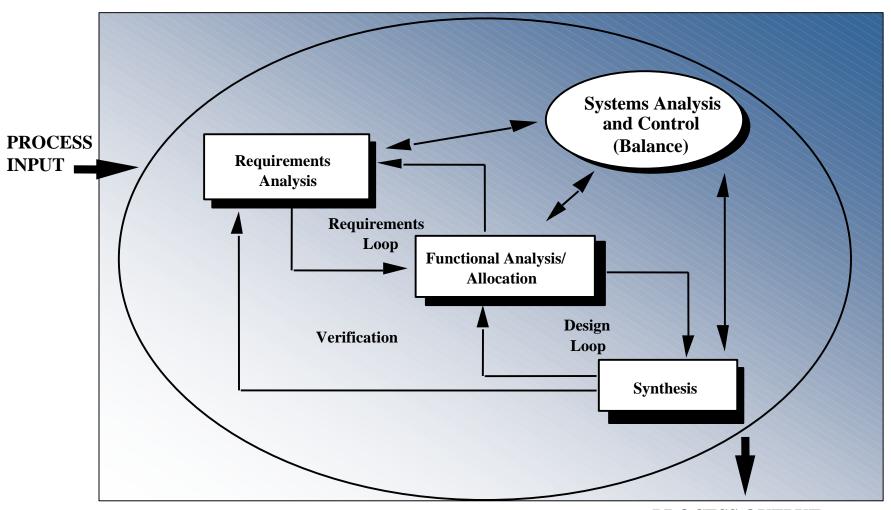
- Given: Integrated Product and Process Development Environment
- An open systems approach must become integral to the systems engineering process
- Does not require a new process or radical changes to our current processes, but...
- Does require a different way of thinking about the products we deliver

Bottom Line: Make the open systems approach a normal

part of your systems engineering process



Systems Engineering Process



PROCESS OUTPUT





IPPD Environment

- Requirements
 - Functional
 - Performance
 - Design
 - Cost
 - Derived
- Constraints
 - Environment
 - Technology
 - Laws & Policies
- Acquisition Strategy
 - Summary of Open Systems Approach





IPPD Environment

Requirements Analysis

- Analyze Reqs/Objectives that could be enabled by an Open Systems Approach
- Assess design constraints & feasibility of open systems
 - Define Functions
 - Define Level of Performance
 - Identify Constraints
 - Compliance requirements
 - Capabilities of interfacing systems
 - Identify Interfaces

An Open System-based Acquisition Strategy



Should Address How a Program Plans to:

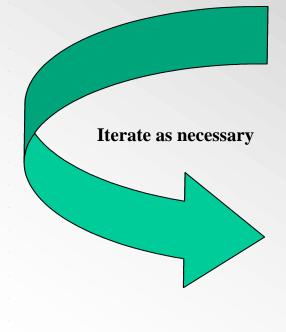
- Evolve the system over its lifetime
- Capitalize on emerging technology
- Control the total ownership costs and reduce the acquisition cycle time
- Enhance long-term supportability
- Achieve interoperability
- Take advantage of competitive marketplace for appropriate items



Functional Analysis/Allocation

IPPD Environment

Functional Analysis/ Allocation

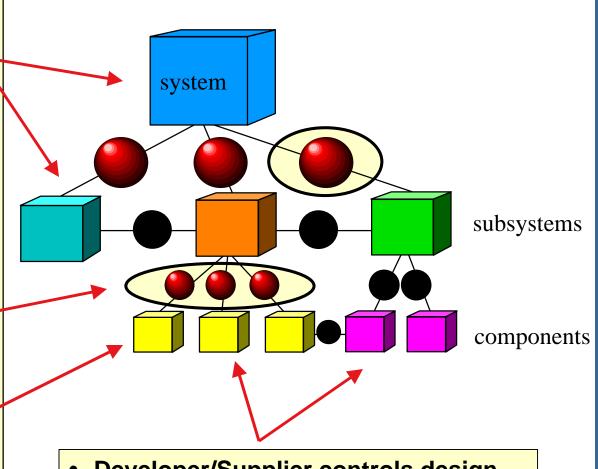


- Partition system into functional modules
- Allocate performance/requirements to functional modules
- Perform trade-offs
- Use Technical Reference Model to define and document interfaces between modules
- Identify key interfaces and assess the feasibility of making them open
- Develop modular standards-based architecture

System Partitioning



- Functionally partitioned modular design
- Disciplined definition of interfaces
- Buyer designate key interfaces
- Buyers decide on use of open standards for key interfaces
- Other interfaces are under supplier control



- Developer/Supplier controls design, interfaces and implementation
- May use open standards

What is a Technical Reference Model?



Abstract Framework to ...

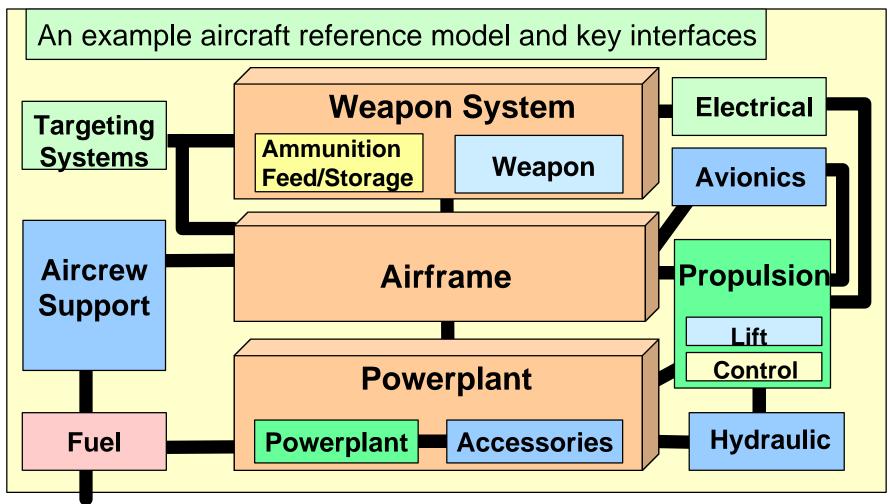
- Promote common understanding
- Identify key interfaces
- Determine appropriate standards

Represents types of functions, interfaces and features used in a system.

The Reference Model <u>is not</u> a Product or System Description!

Example Technical Reference Model



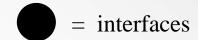


Key Interfaces

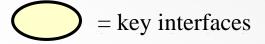


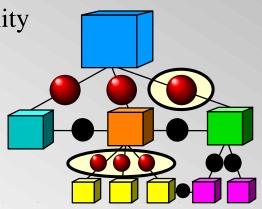
Interfaces between modules with one or more of the following characteristics are good candidates to designate as key interfaces:

- Evolving requirements
- New/additional capabilities envisioned
- Incremental improvements through planned upgrade
- Rapidly changing technology
- High replacement frequency/cost
- Need for commonality and interoperability



= uses open standards









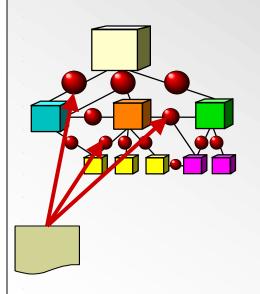
- The program team selects key interfaces
- Key interfaces should be defined using open standards if feasible
- The developer/supplier may use open standards for other interfaces as well
- It may not be possible to use open standards for all of the key interfaces



Synthesis

IPPD Environment

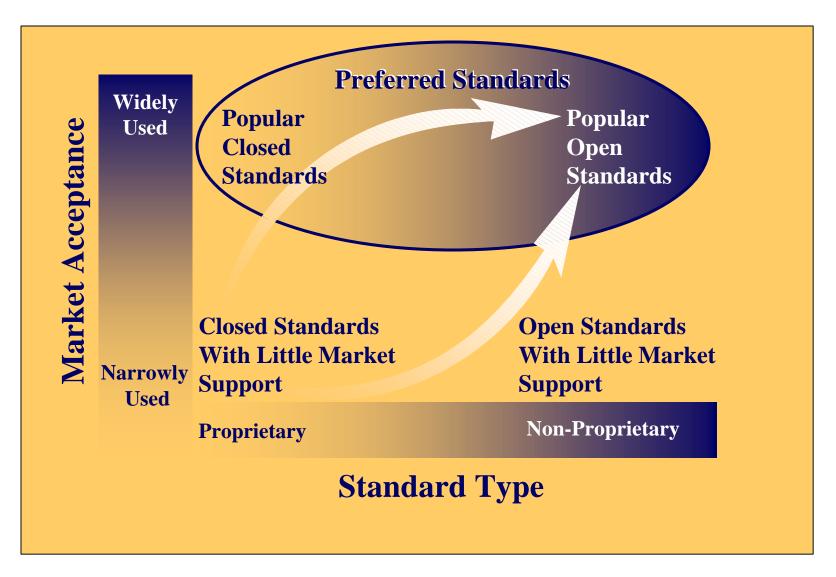
Synthesis



- Select standards for key interfaces
 - Industrial standards organization
 - Market acceptance
- Prototype solutions where possible
- Standardize on interfaces not products
- Implement with products with documented conformance to required standards

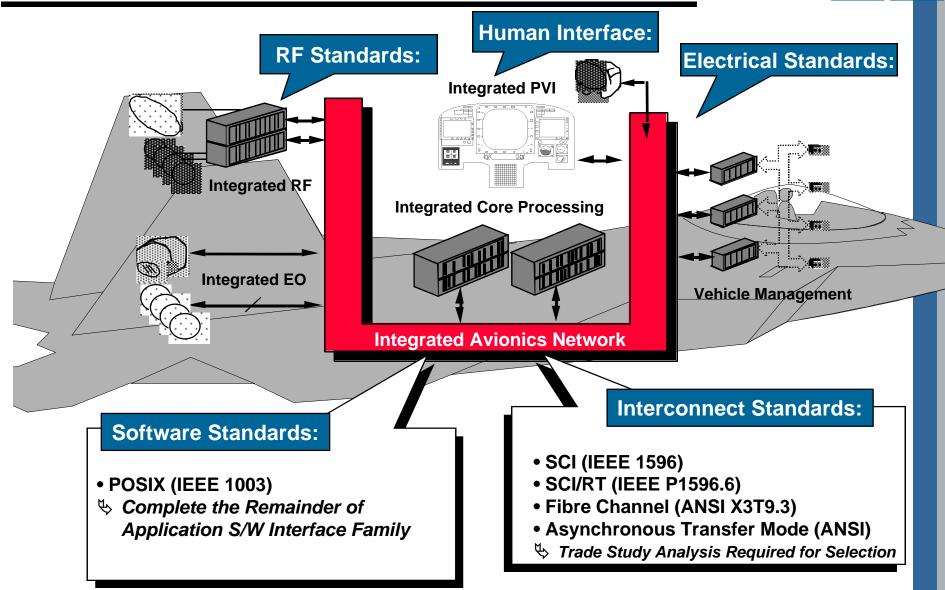
Standards Selection





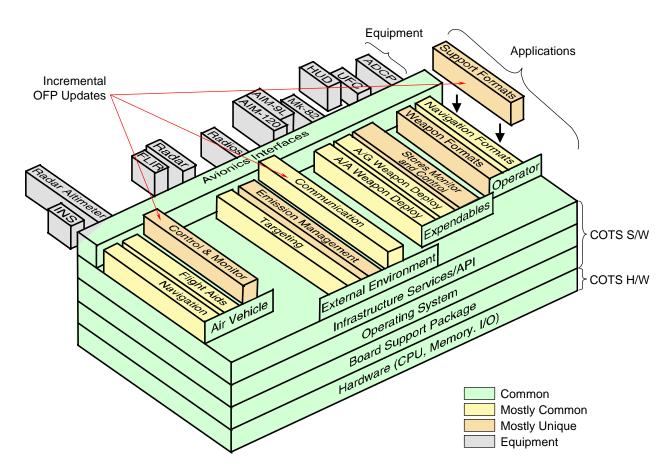






Open Interfaces Isolate Hardware and Software Components





The Layered, Object-Oriented Design Provides O&S Savings by Facilitating Reusable Applications and Permitting OFP Changes and Hardware Updates With Minimal Retesting

Industry Standards Bodies, Consortia & International Military Standards Groups









INTERNATIONAL®



















IPPD Environment

Program plans, for example the Air Force Single Acquisition Management Plan (SAMP), should address:

- Technology upgrades
- Interface management
- Modular open systems architecture

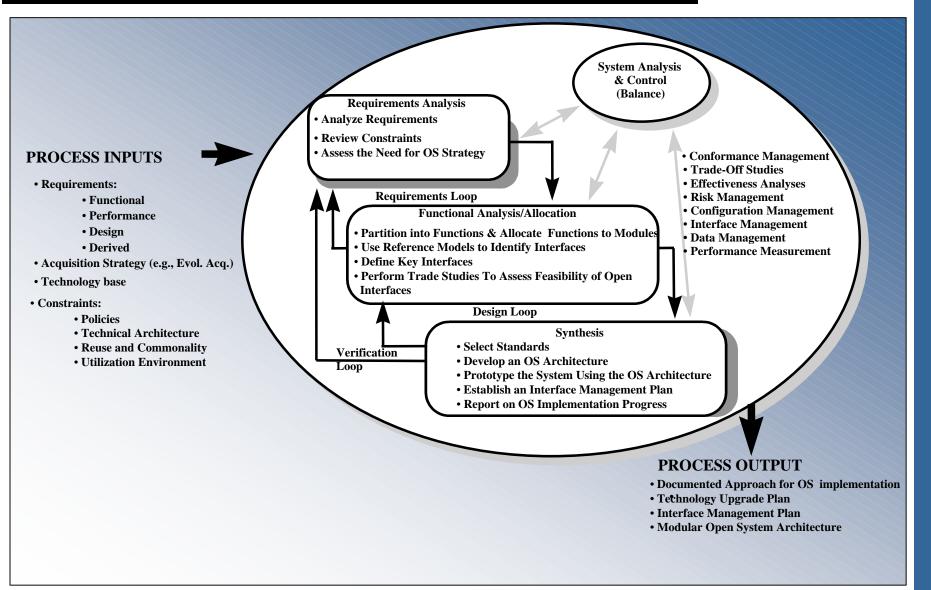
Product: Documented modular open systems approach specific to program

Open Systems Considerations in the SE Process



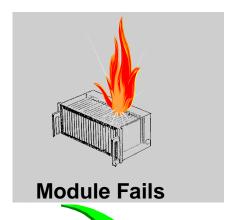


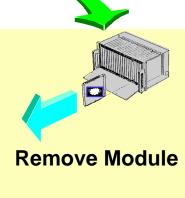


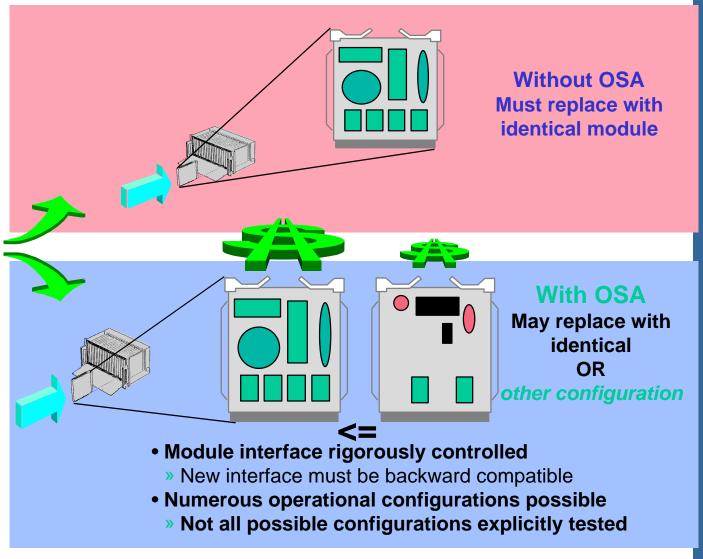


Logistics Support Considerations: Module Replacement or Upgrade?



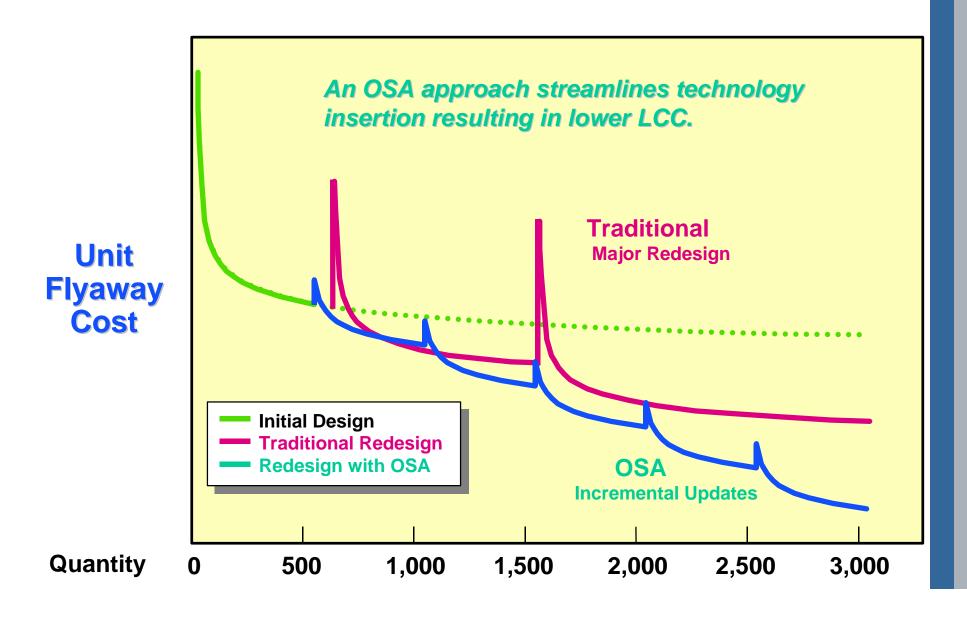






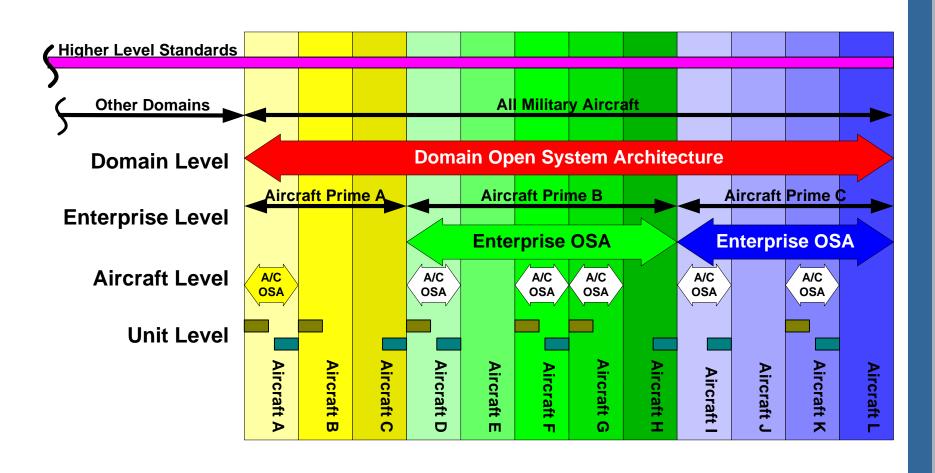
Technology Insertion





Levels of Open System Architectures





Summary



- Create a common understanding of open systems concept before implementing an Open Systems Approach
- Open system is not a panacea and should not be implemented under all circumstances
- Use a modular architecture approach in design of systems
- Follow an open systems approach to address the questions asked at the beginning of the workshop
- Involve the affected parties and provide training on open systems principles and concepts
- Monitor the evolution of standards
- Devise interface and technology management strategies that cover the entire life cycle

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Part I Why an Open Systems Approach?

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Part IV Who is using an Open Systems Approach?

- » Joint Strike Fighter
- **» Open System Avionics Technology Demonstration**
- » Health and Usage Monitoring Systems (HUMS)
- » AV-8B OSCAR / F-15 ADCP
- » Integrated Sensor System (ISS)



Proving Viability of Open Systems

- Pilot Programs
- Demonstration / Risk Reduction Projects
- Prototyping
- Simulation
- Analogies
- LCC Case Studies

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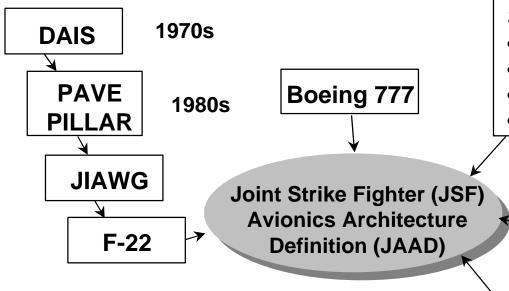
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Context For JSF Avionics Architecture: Legacy Of Modern Fighter Avionics





STRUCTURED SOFTWARE:

- Object Oriented Design
- Ada, C
- Partitioning, Entry/Exit Control
- Type Checking, Info Hiding, etc.

NETWORKING:

- High Speed Interconnect
- Client/Server
- Multi-Level Security

Architecture Provides the Framework for:

- Open Systems ("Building Codes")
- Affordable Development, Integration & Test
- Orderly Modification & Upgrading

DOD INITIATIVES:

- Acquisition Reform / Perry Initiative
- Open Systems Joint Task Force (OS-JTF)
- Joint Technical Architecture (JTA, DII COE)

JAAD Characteristics



- Spans Technical and System Architectures
- **Practical Openness** Emphasis on Integration & Upgrading
- Scalability Achieved by Modular Design & Overall Architecture
- *Domain Confined Timing* Strict Localization of Critical Timing Relationships
- *Failure Management* Embedded Diagnostics/Prognostics Plus Selective Redundancy
- Unified Network Simplify Integration & Modification; Reduce Cost & Weight
- *F*³*I* Where "Function" is Defined as The Set of Behaviors Which a Module Can Exhibit Through Its Interface
- Maximum Feasible Use of COTS & Commercial Standards
- Support for the "ilities" Testability, Maintainability, etc.





• Connectivity:

- Unified Network Protocol
- Links to Other Platforms ("System of Systems")

• Software:

- Higher Order Language(s)
- Real Time Operating System (RTOS) Services
- Application Programming Interface(s) (APIs)
- Graphics Interface
- Data Base Management System Interface
- Object Request Brokers (ORBs, if used)

• Mechanical/Electrical:

- Packaging & Cooling
- Power Distribution

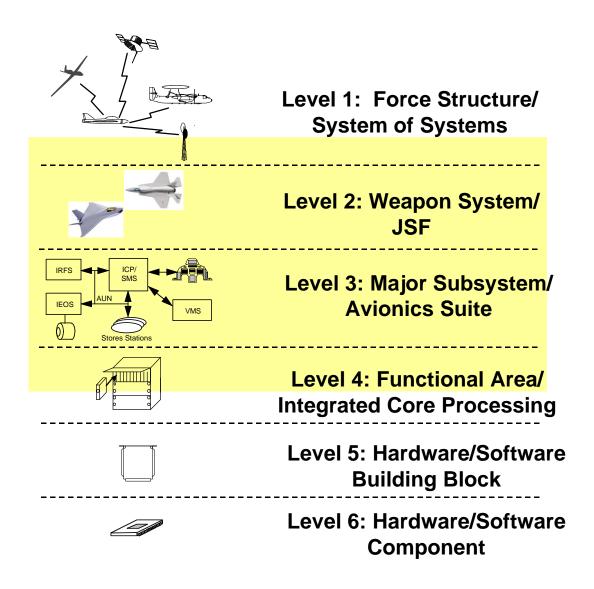
Open Systems Is Key to JSF Acquisition Strategy



- Physical Integration, Functional Federation Is Essential to Performance, Mission Reliability, Supportability & Affordability
- Fighter Avionics Shares Many of the Same Challenges As Those Seen in C⁴ISR Systems
- Open Systems is a Key Enabler for JSF To Operate In the DoD "System of Systems" Context
- Open Systems Enables Ease of Upgrade, Reduced Testing, and Long Term Viability via Modularity
- COTS-Based Components and Standards Can be Major Contributors to Mitigating Technology Obsolescence
- The JAAD Presents a Framework for Avionics Concept Refinement, Technology Maturation, Conformity to DoD Architectural Standards & Development of Building Codes:
 - General Principles & Attributes
 - Overall Structure & Context for Application of Standards

Joint Strike Fighter Architectural Hierarchy





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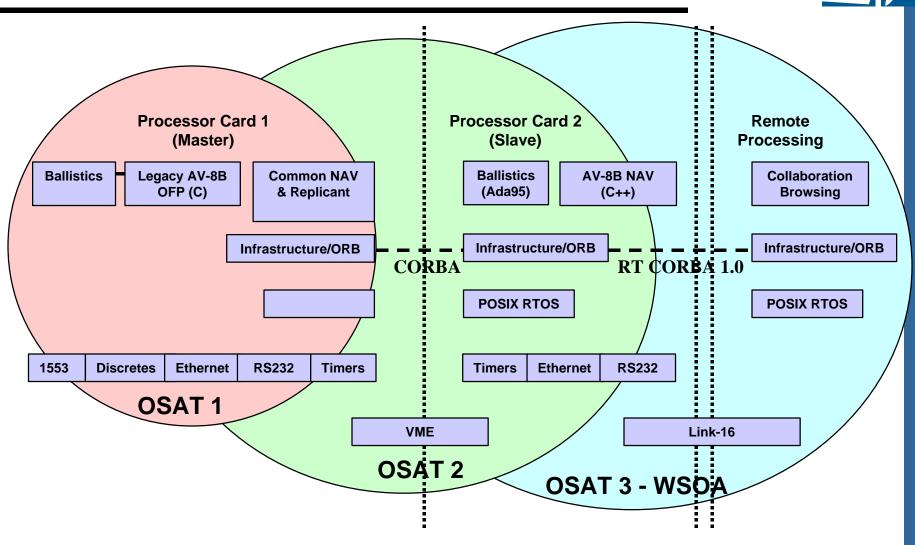
Systems Approach?

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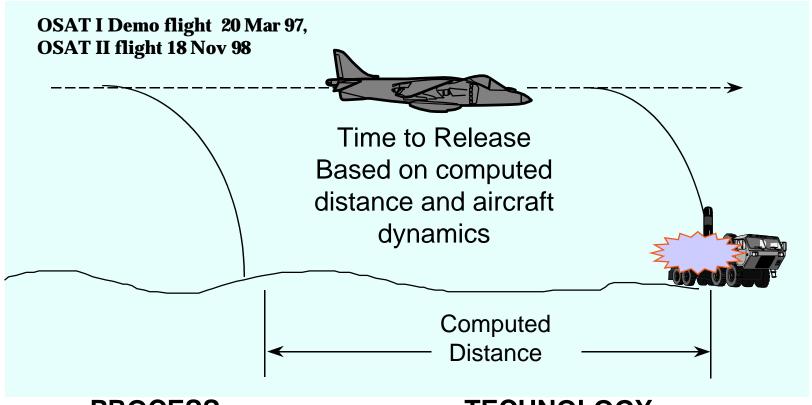
OS-JTF Standards Demonstrations John Task Force





Open System Ada95 Technology (OSAT) Bombing Demonstration





<u>PROCESS</u>

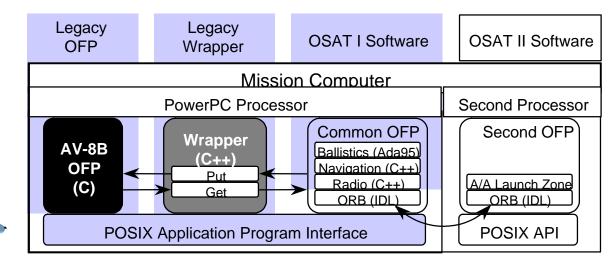
- GDIS Upgrades AYK-14
- Boeing Integrates & Tests
- Demo @ NAWC-WD CL

TECHNOLOGY

- Motorola Power PC Processor
- Green Hills Ada95/C++ Compiler
- Wind River VxWorks OS (POSIX)

Open System Ada95 Technology (OSAT) Risk Reduction Demonstrations





AV-8B

Original XN-6 Mission Computer Modified XN-6 Or All-COTS MC

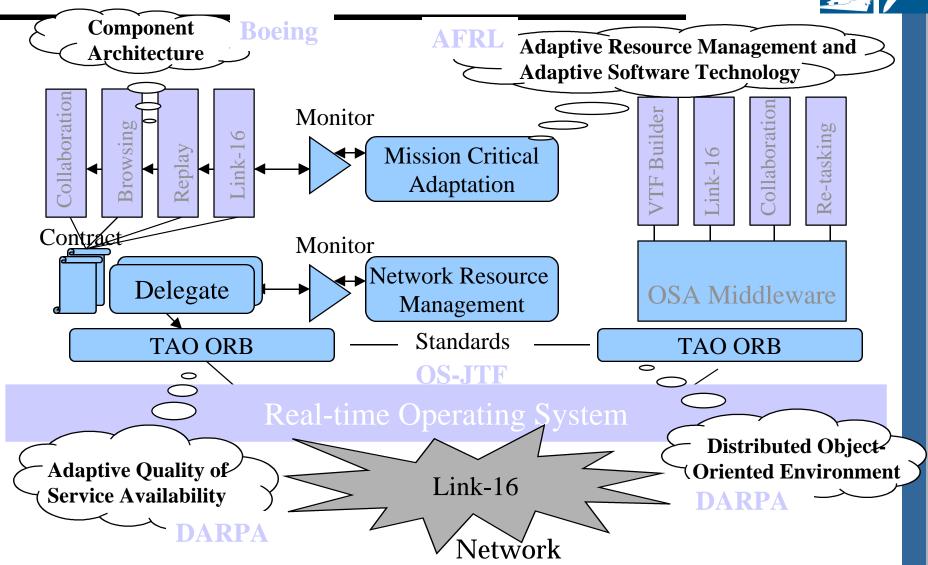


1 COTS Module With PowerPC Replaced 8 Original Modules

Add Second COTS Module For OSAT II

WSOA Leverages Current Efforts

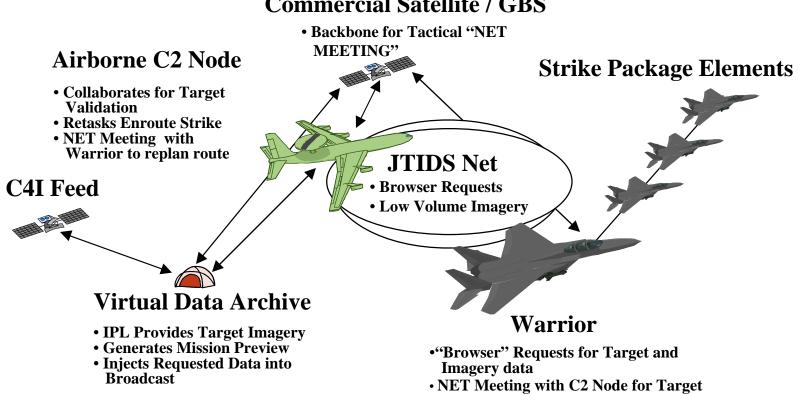




WSOA CONOPS



Commercial Satellite / GBS

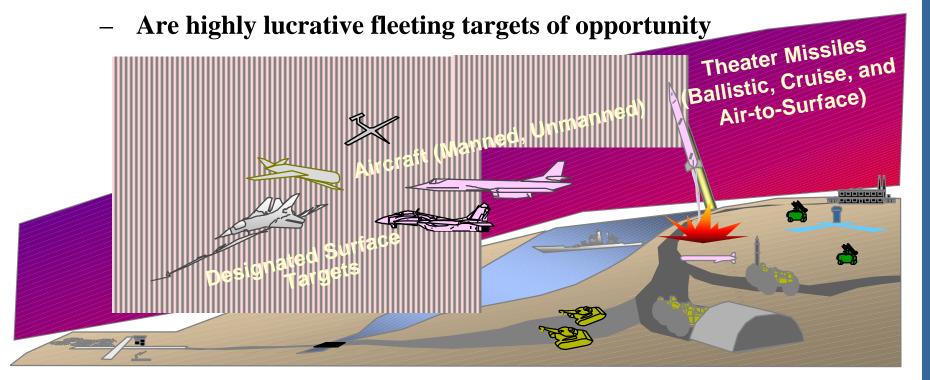


- NET Meeting with C2 Node for Target Review and Mission Replan
- **.**"Browser" Requests for Mission Rehearsal
- Pulls Imagery and Rehearsal Data
- Previews Updated Mission Enroute
- Server for Additional Strike Member

WSOA Supports TCT Prosecution John Task Force



- WSOA is defined in the context of time-critical target attack in the air superiority mission area
- TCTs are targets requiring an immediate response
 - They pose a clear and present danger to friendly forces and



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Health and Usage Monitoring System (HUMS) for Rotary Wing Aircraft



Objectives:

- Use embedded OS-based sensors and diagnostics to predict maintenance problems
- Apply to a wide range of vehicles

Performance:

- Avoid catastrophic failure
- Enable operator efficiencies through common cockpits
- Achieve a scalable architecture through OS

Cost:

- \$450K OS-JTF investment
- Anticipate \$22M in program cost reductions through OS
- Projected reductions in downtime, maintenance, and O&S costs

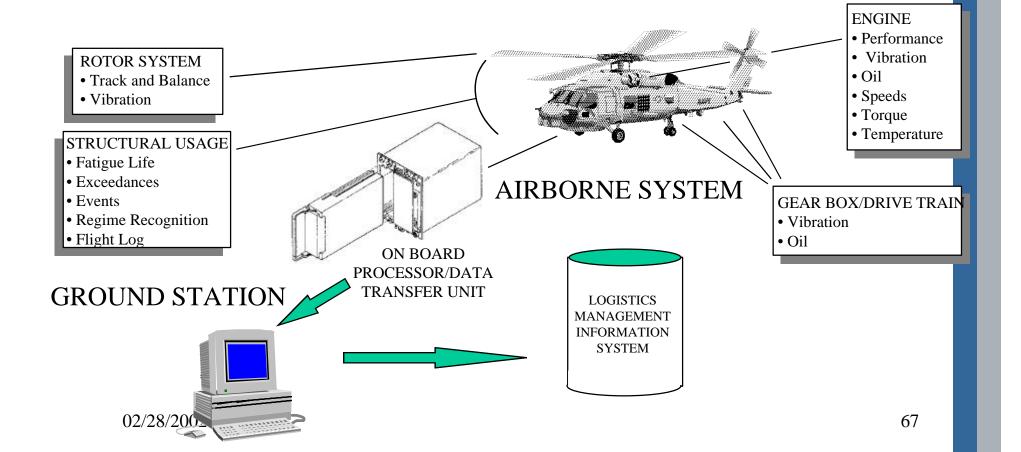
Benefits:

- Improved aircraft safety
- Avoid technical obsolesce
- Achieved common cockpit
- Improved technology insertion and refresh
- Reduced O&S manning and training infrastructure

Integrated Mechanical Diagnostics (IMD)



H-53/SH-60 IMD "Lead the Fleet Program in response to White House Operational Requirements



Rotary Wing Health and Usage Monitoring System



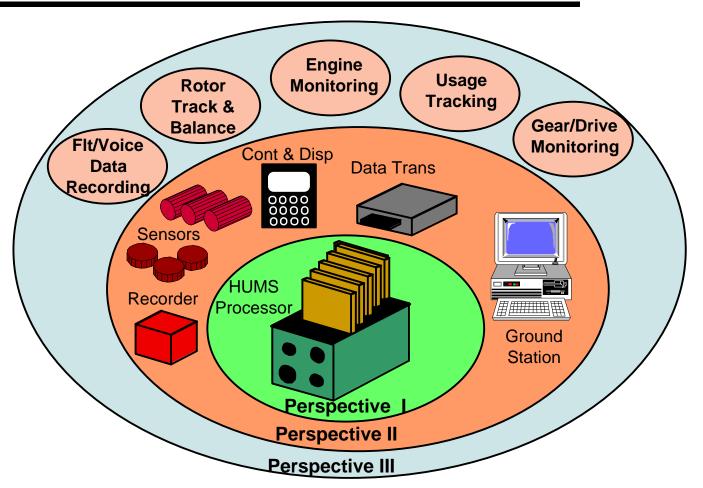
An "Open System" can mean different things depending on the perspective of the viewer

- For Example, one can define three open system architecture perspectives for Health and Usage Monitoring systems used in Navy and Marine H-53Es and H-60s HUMS:
 - Perspective I: HUMS Onboard Processor (HUMS system supplier)
 - Perspective II: Major IMD Components (e.g. sensors, data processor, control & display, recording, data transfer, and ground station)
 (airframe manufacturer)
 - Perspective III: IMD Diagnostic Functions (e.g. rotor track & balance, engine monitoring, gearbox/drive train monitoring, rotor system monitoring)

 (government)



System and Subsystem Perpsectives



We need to to be able to competitively obtain equipment that performs the desired functions from the sources that provide the best value for each function.

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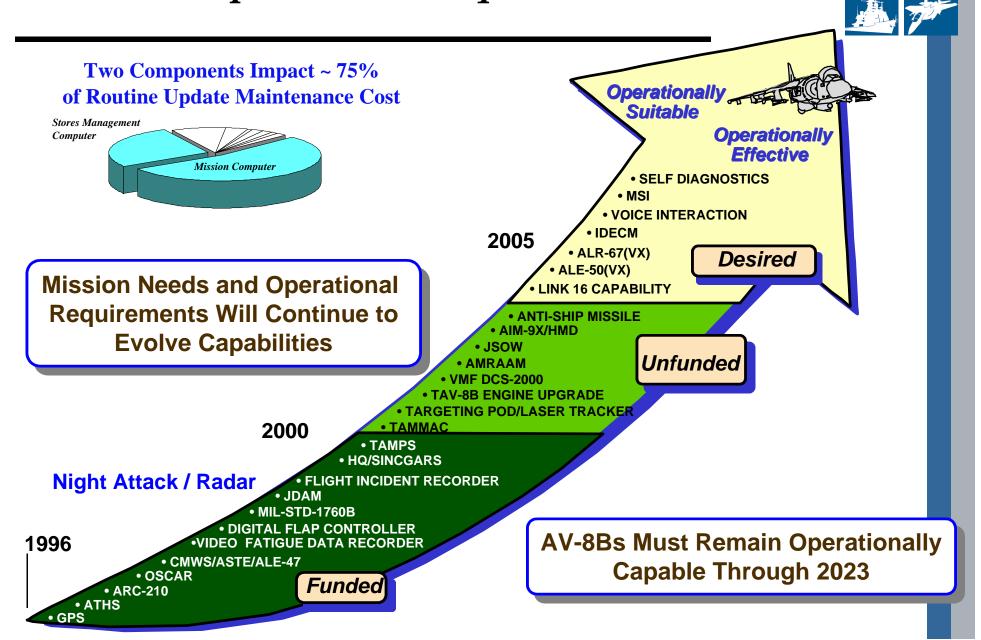
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AV-8B Operational Requirements



A PEO's Perspective



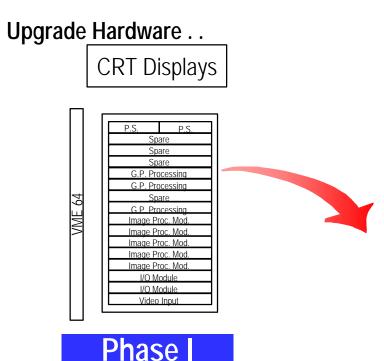
"I have reviewed a weapons system upgrade program on the AV-8B that will prove the case for open systems practices and procedures. It is aggressive, innovative, and on the cutting edge of new acquisition approaches.

OSCAR ... addresses a specific need, ...breaks cyclic and expensive hardware and software upgrades, ...[and] is not a research project, but an infrastructure that supports actual use for one platform and easily assimilates into other USN and USAF aircraft."

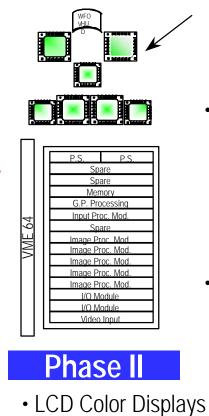
Dan Czelusniak (Then) PEO Air ASW, Assault and Special Mission Programs Memo to PDUSD(A&T), 6 Oct 95

F-15 Multi - Purpose Display Processor (MPDP) Upgrade





- COTS Processor
- Open Backplane
- Incorporates VCC Function



LCD Displays

- Commercial Interfaces
 - VME Standard
 - Fibre Channel I/O
 - Ethernet
 - Standard 6U Form Factor
- Commercial Environment
 - Commercial Processors
 - PerformanceSpecification
 - O to OEM Support

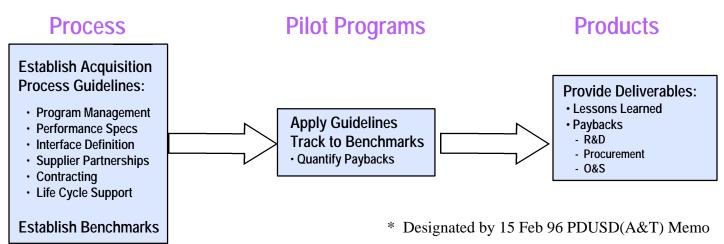
No Group A Impact

... Modular software

VCC - VHSIC Central Computer

A Multi-Service Pilot Program *





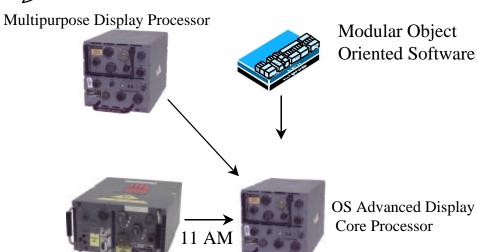


Central Computer

F-15 Advanced Display Core Processor



AV-8B OS Core Avionics Requirement





Original AYK-14 New Mission Compute⁷⁴

Overview



Part I Why an Open Systems Approach?

Part II What is an Open Systems Approach?

Part III How do you implement an Open

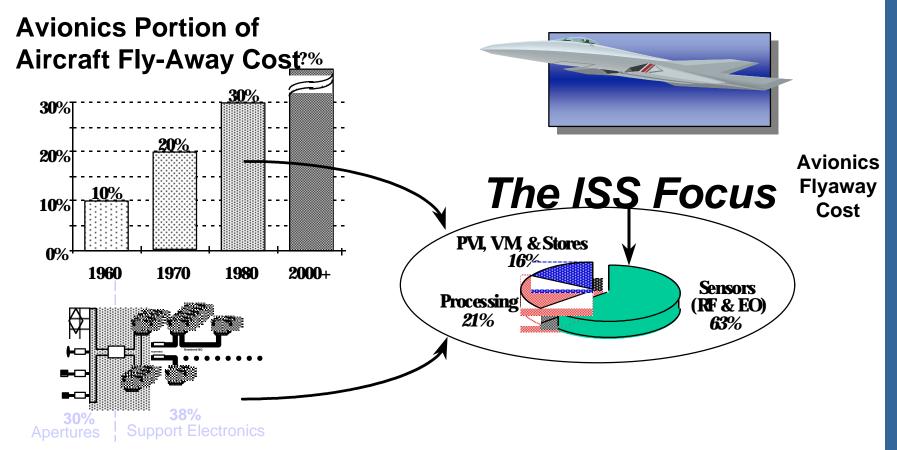
Systems Approach?

Part IV Who is using an Open Systems Approach?

- » Joint Strike Fighter
- » Open System Avionics Technology Demonstration
- » Health and Usage Monitoring Systems (HUMS)
- » AV-8B OSCAR / F-15 ADCP
- » Integrated Sensor System (ISS)

The Problem: Affordability

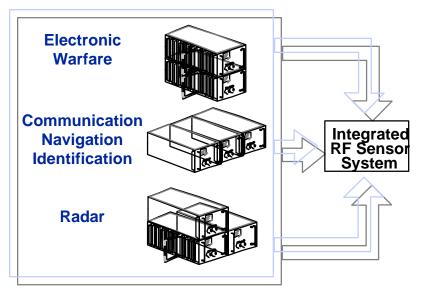




Preliminary USAF PAVE PACE Studies showed that an Integrated RF Sensor System could reduce cost and weight of RF Electronics by as much as 50%

ISS Payoffs





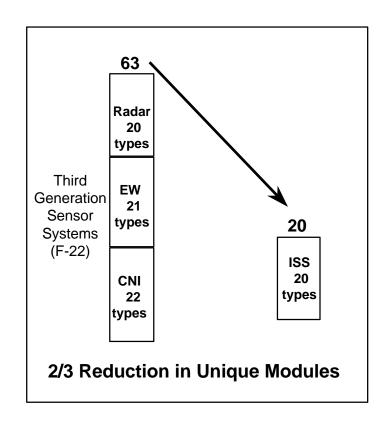
Current 3rd Generation Avionics (F-22)

ISS: Extending PILLAR Concepts into Sensor Area

- Common Modules
- Resource Sharing
- Testability
- Reconfiguration
- Growth Flexibility

Full RF Capability

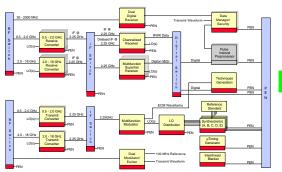
- 1/2 Cost
- 3X Reliability
- 1/2 Weight/Vol

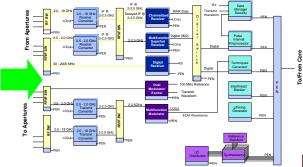


Module Dev Cost Over \$1M each

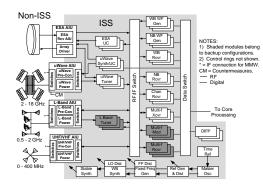
ISS Architecture Reconciliation



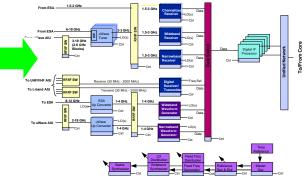


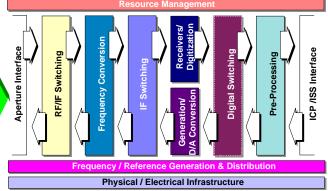


Original ISS Architecture Diagrams



Redrawn ISS Architecture Diagrams

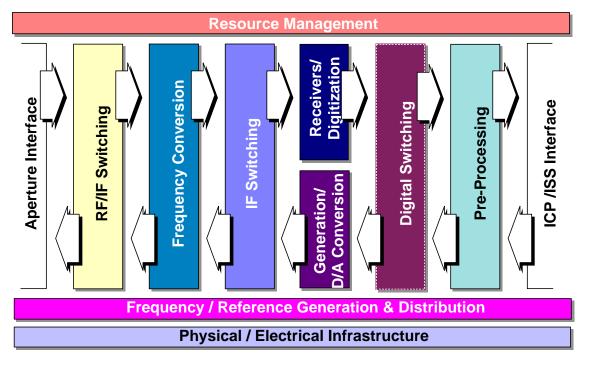




ISS OSA Functional Partitioning Model

ISS OSA Framework (Functional Partitioning)

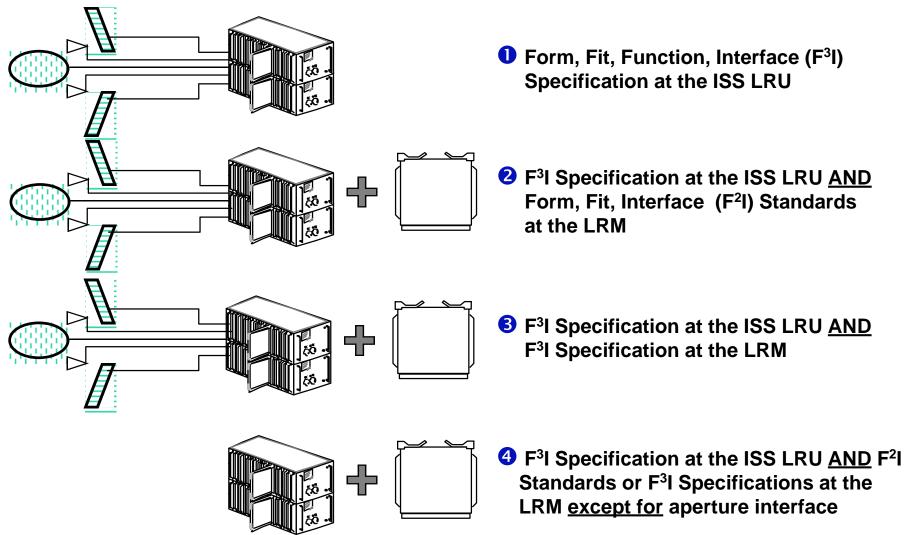




- Generated a Generic OSA
 Framework Common to Both
 Team's ISS Architectures
- Applied OS-JTF Sponsored GOA Architecture for Infrastructure Architecture Elements
- Built Upon JAST Avionics Architecture Definition Document for Functional Architecture Elements
- Mapped ISS Elements Into Partitioned Functional Elements for Defining Interfaces
- Listed ISS Attributes and Assessed Potential for Standardization
- > Coordinated With JSF Programs: MIRFS and ICR

ISS OSA Standardization Options





Questions



- •Who determines the Degree of Openness?
 - **⇔** Government?
 - ❖ Industry?
- •At what level?
 - ⇒ System of Systems (SOS)
 - ⇒ Weapon System Platform
 - ⇒ System/Subsystem
 - ⇒ "Black Box"
 - ⇒ Piece Part
- •Scope/Purview?
 - Single Acquisition/Case-by Case
 - ⇒ PEO or User Portfolio/Domain
 - Corporate Product Line

Key Questions - Revisited



This workshop will help you find answers to the following questions:

- ✓ What is an open systems approach and why we need to pursue one?
- **✓** How are you going to take advantage of emerging products and technologies?
- **✓** How do you ensure a future technology insertion capability?
- **✓** How are you going to control cost?
- **✓** How are you going to evolve your system over its extended lifetime?
- **✓** How are you going to mitigate risks?
- **✓** What provisions have been made to ensure competition throughout the program life cycle?